

CLAIMS

Having thus described our invention what we claim as new  
and desire to secure as Letters Patent, is:

254/5004 1 2 3 4 5 6 7  
1. A superconductive composition having a transition  
temperature greater than 26°K, the composition in-  
cluding a rare earth or ~~near~~ rare earth-like ele-  
ment, a transition metal element capable of  
exhibiting multivalent states and oxygen, and in-  
cluding at least one phase that exhibits  
superconductivity at temperature in excess of 26°K.

1 2 3 4  
2. The composition of claim 1, further including an  
alkaline earth element substituted for at least one  
atom of said rare earth or rare earth-like element  
in said composition.

1 2  
3. The composition of claim 2, where said transition  
metal is (Cu.)

1 4. The composition of claim 3, where said alkaline earth  
2 element is selected from the group consisting of  
3 <sup>BE</sup>  
B, Ca, Ba, and Sr.

1 5. The composition of claim 1, where said transition  
2 metal element is selected from the group consisting  
3 of Cu, Ni, and Cr.

1 6. The composition of claim 2, where said rare earth  
2 or rare earth-like element is selected from the  
3 group consisting of La, Nd, and Ce.

1 7. The composition of claim 1, where said phase is  
2 crystalline with a perovskite-like structure.

1 8. The composition of claim 2, where said phase is  
2 crystalline with a perovskite-like structure.

1 9. The composition of claim 1, where said phase exhibits  
2 a layer-like crystalline structure.

1 10. The composition of claim 1, where said phase is a  
2 mixed copper oxide phase.

1 11. The composition of claim 1, where said composition  
2 is comprised of mixed oxides with alkaline earth  
3 doping.

1 12. A superconducting combination, including a  
2 superconductive composition having a transition  
3 temperature  $> 26^{\circ}\text{K}$ ,

4 means (for) passing a superconducting electrical  
5 current through said composition while said compo-  
6 sition is at a temperature  $> 26^{\circ}\text{K}$ , and

7 cooling means for cooling said composition to a  
8 superconducting state at a temperature in excess  
9 of  $26^{\circ}\text{K}$ .

1 13. The combination of claim 12, where said  
2 superconductive composition includes a transition  
3 metal oxide.

1 14. The combination of claim 12, where said  
2 superconductive composition includes Cu-oxide.

1 15. The combination of claim 12, where said  
2 superconductive composition includes a multivalent  
3 transition metal, oxygen, and at least one addi-  
4 tional element.

1 16. The combination of claim 15, where said transition  
2 metal is Cu.

1 17. The combination of claim 15, where said additional  
2 element is a rare earth or rare earth-like element.

1 18. The combination of claim 15, where said additional  
2 element is an alkaline earth element.

1 19. The combination of claim 12, where said composition  
2 includes a perovskite-like superconducting phase.

1 20. The combination of claim 12, where said composition  
2 includes a substituted transition metal oxide.

1 21. The combination of claim 20, where said substituted  
2 transition metal oxide includes a multivalent  
3 transition metal element.

1 22. The combination of claim 20, where said substituted  
2 transition metal oxide is an oxide of copper.

1 23. The combination of claim 20, where said substituted  
2 transition metal oxide has a layer-like structure.

1 24. A method including the steps of forming a transition  
2 metal oxide having a phase therein which exhibits  
3 a superconducting state at a critical temperature  
4 in excess of 26° K,

B 5 *maintaining*  
6 ~~lowering~~ the temperature of said material at *a temperature less than* ~~least~~  
7 ~~to~~ said critical temperature to produce said  
superconducting state in said phase, and

8 passing an electrical supercurrent through said  
9 transition metal oxide while it is in said super-  
10 conducting state.

1 25. The method of claim 24, where said transition metal  
2 oxide is comprised of a transition metal capable  
3 of exhibiting multivalent states.

1 26. The method of claim 24, where said transition metal  
2 oxide is comprised of a Cu oxide.

1 27. A superconducting composition having a transition  
2 temperature in excess of 26°K, said composition  
3 being a substituted Cu-oxide including a supercon-  
4 ducting phase having a structure substantially  
5 close to the orthorhombic-tetragonal phase transi-  
6 tion of said composition.

1 28. The composition of claim 27, where said substituted  
2 Cu-oxide includes a rare earth or rare earth-like  
3 element.

1 29. The composition of claim 27, where said substituted  
2 Cu-oxide includes an alkaline earth element.

1 30. The composition of claim 29, where said alkaline  
2 earth element is atomically large with respect to  
3 Cu.

1 31. The composition of claim 27, where said composition  
2 has a crystalline structure which enhances  
3 electron-phonon interactions to produce  
4 superconductivity at a temperature in excess of  
5 26°K.

1 32. The composition of claim 31, where said crystalline  
2 structure is layer-like, enhancing the number of  
3 Jahn-Teller polarons in said <sup>composition</sup> composite.

1 33. A superconducting composition having a supercon-  
2 ducting onset temperature in excess of 26°K., the  
3 composition being comprised of a copper oxide doped  
4 with an alkaline earth element where the concen-

5 tration of said alkaline earth element is near to  
6 the concentration of said alkaline earth element  
7 where the superconducting copper oxide phase in  
8 said composition undergoes an orthorhombic to  
9 tetragonal structural phase transition.

2 34. A superconducting composition having a supercon-  
3 ducting onset temperature in excess of 26°K, the  
4 composition being comprised of a mixed copper oxide  
5 doped with an element chosen to create Cu<sup>3+</sup> ions  
in said composition.

1 35. The composition of claim 34, where said doping el-  
2 ement includes an alkaline earth element.

1 36. A combination comprising:

2 a composition having a superconducting onset tem-  
3 perature in excess of 26°K, said composition being  
4 comprised of a substituted copper oxide exhibiting  
5 mixed valence states and at least one other element  
6 in its crystalline structure,



B 7 means for passing a superconducting electrical  
8 current through said composition while said compo-  
9 sition is at a temperature in excess of 26°K, ~~and~~

10 cooling means for cooling said composition to a  
11 superconducting state at a temperature in excess  
12 of 26°K.

1 37. The combination of claim 36, where said at least  
2 one other element is an alkaline earth element.

1 38. The combination of claim 36, where said at least  
2 one other element is an element which creates Cu<sup>3+</sup>  
3 ions in said composition.

1 39. The composition of claim 36, where said at least  
2 one other element is an element chosen to create  
3 the presence of both Cu<sup>2+</sup> and Cu<sup>3+</sup> ions in said  
4 composition.

1 40. A superconductor exhibiting a superconducting onset  
2 at a temperature in excess of 26°K, said supercon-  
3 ductor being comprised of at least four elements,  
4 none of which is itself superconducting.

1 41. The superconductor of claim 40, where said elements  
2 include a transition metal and oxygen.

1 42. A superconductor having a superconducting onset  
2 temperature greater 26°K, said superconductor being  
3 a doped transition metal oxide, where said transi-  
4 tion metal is itself non-superconducting.

1 43. The superconductor of claim 42, where said doped  
2 transition metal oxide is multivalent in said  
3 superconductor.

1 44. The superconductor of claim 42, further including  
2 an element which creates a mixed valent state of  
3 said transition metal.

1 45. The superconductor of claim 43, where said transi-  
2 tion metal is Cu.

B 1 46. A superconductor having a superconducting onset  
2 temperature greater than 26°K, said superconductor  
3 being an oxide having multivalent oxidation states  
4 and including a metal, said oxide having a crys-  
5 talline structure which is oxygen deficient.

1 47. The superconductor of claim 46, where said transi-  
2 tion metal is Cu.

1 48. A superconductive composition comprised of a tran-  
2 sition metal oxide having substitutions therein,  
3 the amount of said substitutions being sufficient  
4 to produce sufficient electron-phonon interactions  
5 in said composition that said composition exhibits  
6 a superconducting onset at temperatures greater  
7 than 26°K.

1 49. The composition of claim 48, where said transition  
2 metal oxide is multivalent in said composition.

1 50. The composition of claim 48, where said transition  
2 metal is Cu.

1 51. The composition of claim 48, where said substi-  
2 tutions include an alkaline earth element.

1 52. The composition of claim 48, where said substi-  
2 tutions include a rare earth or rare earth-like  
3 element.

1 (53) A superconductor comprised of a copper oxide having  
2 a layer-like crystalline structure and at least one  
3 additional element substituted in said crystalline  
4 structure, said structure being oxygen deficient  
5 and exhibiting a superconducting onset temperature  
6 in excess of 26°K.

1 54. The superconductor of claim 53, where said addi-  
2 tional element creates a mixed valent state of said  
3 copper oxide in said superconductor.

1 55. A combination, comprising:

2 a transition metal oxide having an oxygen defi-  
3 ciency, said transition metal being non-  
4 superconducting and said oxide having multivalent  
5 states,

6 means for passing an electrical superconducting  
7 current through said oxide while said oxide is at  
B 8 a temperature greater than 26°K, <sup>therefore</sup> ~~and~~

9 cooling means for cooling said oxide in a super-  
10 conducting state at a temperature greater than  
11 26°K.

1 56. The combination of claim 55, where said transition  
2 metal is Cu.

1 57. A combination including;  
2 a superconducting oxide having a superconducting onset  
3 temperature in excess of 26°K and containing at least 3  
4 non-superconducting elements,  
5 means for passing a supercurrent through said oxide  
6 while said oxide is maintained at a temperature greater  
7 than 26°K, and  
8 means for maintaining said oxide in a superconducting  
9 state at a temperature greater than 26°K.

1 58. A combination, comprised of:  
2 a copper oxide superconductor including an element which  
3 creates a mixed valent state in said oxide, said oxide  
4 being crystalline and having a layer-like structure,  
5 means for passing a supercurrent through said copper  
6 oxide while it is maintained at a temperature greater  
7 than 26°K, and

B

8

9

*maintaining*  
means for ~~cooling~~ *IN* said copper oxide to a superconductive state at a temperature greater than 26°K.

1

59

A combination, comprised of:

2

3  
4

a superconducting ceramic-like material having an onset of superconductivity at a temperature in excess of 26°K.,

5

6

7

8

means for passing a supercurrent through said superconducting ceramic-like material while said ceramic-like material is maintained at a temperature in excess of 26°K., and

B

9

B 10

11

*maintaining*  
means for ~~cooling~~ *IN* said superconducting ceramic-like material to a superconductive state at a temperature greater than 26°K.

1

60

2

3

4

A superconductor comprised of a transition metal oxide, and at least one additional element, said superconductor having a distorted crystalline structure characterized by an oxygen deficiency and

5 exhibiting a superconducting onset temperature in  
6 excess of 26°K.

1 61. The superconductor of claim 60, where said transi-  
2 tion metal is Cu.

1 62. A superconductor comprised of a transition metal  
2 oxide and at least one additional element, said  
3 superconductor having a distorted crystalline  
4 structure characterized by an oxygen excess and  
5 exhibiting a superconducting onset temperature in  
6 excess of 26°K.

*relative to what*

1 63. The superconductor of claim 62, where said transi-  
2 tion metal is Cu.

1 64. A combination, comprising:

2 a mixed copper oxide composition having enhanced  
3 polaron formation, said composition including an  
4 element causing said copper to have a mixed valent



5 state in said composition, said composition further  
6 having a distorted octahedral oxygen environment  
7 leading to a  $T_c$  greater than  $26^\circ\text{K}$ .

8 means for providing a supercurrent through said  
B 9 composition at temperatures greater than  $26^\circ\text{K}$ , and

10 cooling means for cooling said composition to a  
11 temperature greater than  $26^\circ\text{K}$ .

1 65. A superconducting composition exhibiting  
2 superconductivity at temperatures greater than  
3  $26^\circ\text{K}$ , said composition being a ceramic-like mate-  
4 rial in the RE-AE-TM-O system, where RE is a rare  
5 earth or near rare earth element, AE is an alkaline  
6 earth element, TM is a multivalent transition metal  
7 element having at least two valence states in said  
8 composition, and O is oxygen, the ratio of the  
9 amounts of said transition metal in said two va-  
10 lence states being determined by the ratio RE : AE.

1 66. A superconductive composition having a transition  
2 temperature greater than  $26^\circ\text{K}$ , the composition in-

3 cluding a multivalent transition metal oxide and  
4 at least one additional element, said composition  
5 having a distorted orthorhombic crystalline struc-  
6 ture.

1 67. The composition of claim 66, where said transition  
2 metal oxide is a mixed copper oxide.

1 68. The composition of claim 67, where said one addi-  
2 tional element is an alkaline earth element.

1 69. A superconductive combination, comprising:

2 a superconducting composition exhibiting a super-  
3 conducting transition temperature greater than  
4 26°K, said composition being a transition metal  
5 oxide having a distorted orthorhombic crystalline  
6 structure, and

7 means for passing a superconducting electrical  
8 current through said composition while said compo-  
9 sition is at a temperature greater than 26°K.

1 70. The combination of claim 69, where said transition  
2 metal oxide is a mixed copper oxide.

1 71. The combination of claim 70, where said mixed copper  
2 oxide includes an alkaline earth element.

1 72. The combination of claim 71, where said mixed copper  
2 oxide further includes a rare earth or rare earth-  
3 like element.

1 73. A method for making a superconductor having a  
2 superconducting onset temperature  $> 26^{\circ}\text{K}$ , said  
3 method including the steps of:

4 preparing powders of oxygen-containing compounds  
5 of a rare earth or rare earth-like element, an  
6 alkaline earth element, and copper,

7 mixing said compounds and firing said mixture to  
8 create a mixed copper oxide composition including  
9 said alkaline earth element and said rare earth or  
10 rare earth-like element, and

11 annealing said mixed copper oxide composition at  
12 an elevated temperature less than about 950°C in  
13 an atmosphere including oxygen to produce a super-  
14 conducting composition having a mixed copper oxide  
15 phase exhibiting a superconducting onset temper-  
16 ature greater than 26°K, said superconducting com-  
17 position having a layer-like crystalline structure  
18 after said annealing step.

1 74. The method of claim 73, where the amount of oxygen  
2 incorporated into said composition is adjusted by  
3 said annealing step, the amount of oxygen therein  
4 affecting the critical temperature  $T_c$  of the  
5 superconducting composition.

1 (75.) A method for making a superconductor having a  
2 superconducting onset temperature greater than  
3 26°K, said superconductor being comprised of a rare  
4 earth or rare earth-like element (RE), an alkaline  
5 earth element (AE), copper (CU), and oxygen (O) and  
6 having the general formula RE-AE-CU-O, said method  
7 including the steps of combining said rare earth  
8 or rare earth-like element, said alkaline earth

9 element and said copper in the presence of oxygen  
10 to produce a mixed copper oxide including said rare  
11 earth or rare earth-like element and said alkaline  
12 earth element therein, and

13 heating said mixed copper oxide to produce a  
14 superconductor having a crystalline layer-like  
15 structure and exhibiting a superconducting onset  
16 temperature greater than 26°K, the critical tran-  
17 sition temperature of said superconductor being  
18 dependent on the amount of said alkaline earth el-  
19 ement therein.

1 76. The method of claim 75, where said heating step is  
2 done in an atmosphere including oxygen.

1 77. A combination, comprising:

2 a mixed copper oxide composition including an  
3 alkaline earth element (AE) and a rare earth or  
4 rare earth-like element (RE), said composition  
5 having a layer-like crystalline structure and  
6 multi-valent oxidation states, said composition

7 exhibiting a substantially zero resistance to the  
B 8 flow of electrical current therethrough when <sup>IN</sup> cooled  
B 9 to a superconducting state at a temperature in ex-  
10 cess of 26°K, and

11 electrical means for passing an electrical super-  
12 current through said composition when said compo-  
13 sition exhibits substantially zero resistance at a  
14 temperature greater than 26°K.

1 78. The combination of claim 77, where the ratio  
2 (AE,RE) : Cu is substantially 1:1.

B 1 79. The combination of claim 77, where the ratio  
2 (AE,RE) : Cu is substantially <sup>3:1.</sup> ~~1:1.~~

1 80. The combination of claim 77, where said crystalline  
2 structure is perovskite-like.

1 81. The combination of claim 77, where said mixed copper  
2 oxide composition has a non-stoichiometric amount  
3 of oxygen therein.

1 82. A method for making a superconductor having a  
2 superconducting onset temperature greater than 26°,  
3 said superconductor being comprised of a rare earth  
4 or rare earth-like element (RE), an alkaline earth  
5 element (AE), a transition metal element (TM), and  
6 oxygen (O) and having the general formula  
7 RE-AE-TM-O, said method including the steps of  
8 combining said rare earth or rare earth-like ele-  
9 ment, said alkaline earth element and said transi-  
10 tion metal element in the presence of oxygen to  
11 produce a mixed transition metal oxide including  
12 said rare earth or rare earth-like element and said  
13 alkaline earth element therein, and

14 heating said mixed transition metal oxide to  
15 produce a <sup>superconductor</sup> ~~superconductor~~ having a crystalline  
16 layer-like structure and exhibiting a supercon-  
17 ducting onset temperature greater than 26°K, said  
18 superconductor having a non-stoichiometric amount  
19 of oxygen therein.

1 83. The method of claim 82, where said transition metal  
2 is copper.

1 84. A superconducting combination, comprising:

2 a mixed transition metal oxide composition con-  
3 taining a non-stoichiometric amount of oxygen  
4 therein, a transition metal and at least one addi-  
5 tional element, said composition having substan-  
6 tially zero resistance to the flow of electricity  
B 7 therethrough when cooled to a superconducting state  
8 at a temperature greater than 26°K, and

9 electrical means for passing an electrical super-  
10 current through said composition when said compo-  
11 sition is in said superconducting state at a  
12 temperature greater than 26°K.

1 85. The combination of claim 84, where said transition  
2 metal is copper.

1 86. A method, comprising the steps of:



2 forming a composition including a transition metal,  
3 a rare earth or rare earth-like element, an  
4 alkaline earth element, and oxygen, where said  
5 composition is a mixed transition metal oxide hav-  
6 ing a non-stoichiometric amount of oxygen therein  
7 and exhibiting a superconducting state at a tem-  
8 perature greater than 26°K,

9 *maintaining*  
10 ~~cooling~~ said composition *IN* to said superconducting  
state at a temperature greater than 26°K, and

11 passing an electrical current through said compo-  
12 sition while said composition is in said supercon-  
13 ducting state.

1 87. The method of claim 86, where said transition metal  
2 is copper.

1 88. A method, including the steps of:

2 forming a composition exhibiting a superconductive  
3 state at a temperature in excess of 26°K,

B 4 *maintaining* *at*  
~~cooling~~ said composition to a temperature in excess  
5 of 26°K at which temperature said composition ex-  
6 hibits said superconductive state, and  
  
7 passing an electrical current through said compo-  
8 sition while said composition is in said  
9 superconductive state.

1 89. The method of claim 88, where said composition is  
2 comprised of a metal oxide.

*mod*  
1 90. The metal of claim 88, where said composition is  
2 comprised of a transition metal oxide.

*Add B2  
+ E1*

*add  
271  
Add  
K1*